CLAIMS

What is claimed is:

1. A fuel injection system for a gas turbine, comprising:

a pilot fuel injector;

a pilot swirler for swirling air past the pilot fuel injector;

a main airblast fuel injector;

inner and outer main swirlers for swirling air past the main airblast fuel injector; and

an air splitter, located between the pilot swirler and the inner main swirler, the air splitter being so arranged and constructed to divide a pilot air stream exiting the pilot swirler and the air splitter, from a main air stream exiting the inner main swirler, whereby a bifurcated recirculation zone is created between the pilot air stream and the main air stream.

2. The system of claim 1, further comprising:

a fuel supply control system for providing fuel only to the pilot fuel injector at lower power conditions, and for providing fuel to both the pilot fuel injector and the main airblast fuel injector at higher power conditions.

3. The system of claim 1, wherein:

the main airblast fuel injector includes an atomizer filmer lip having an aft end; and

the air splitter has an aft end angled radially inboard and axially positioned upstream of the aft end of the atomized filmer lip of the main airblast fuel injector.

4. The system of claim 1, further comprising:

an outwardly flared wall downstream of the main airblast fuel injector, the flare ending at an angle in the range of 45° to 70° to a central axis of the main airblast fuel injector.

5. The system of claim 4, wherein:

the outwardly flared outer wall has a length from an aft end of the main airblast fuel injector to an aft end of the outer wall sufficiently short to prevent autoignition of fuel within the outer wall.

6. The system of claim 4, wherein:

the outwardly flared outer wall has a length from an aft end of the main airblast fuel injector to an aft end of the outer wall sufficiently short to prevent main fuel wetting of the flared outer wall.

7. The system of claim 1, wherein:

the pilot fuel injector is a pressure atomizer; and

the pilot swirler surrounds the pressure atomizer.

8. The system of claim 1, wherein:

the swirlers are constructed such that from 5 to 20% of total airflow is through the pilot swirler, from 30 to 70% of total airflow through the swirlers is through the inner main swirler, and the balance of total airflow is through the outer main swirler.

9. The system of claim 1, wherein:

the pilot fuel injector is a pilot airblast fuel injector; and

the pilot swirler includes inner and outer pilot swirlers located inward and outward of the pilot airblast fuel injector.

10. The system of claim 9, wherein:

the swirlers are constructed such that 1 to 10% of total airflow through the swirler is through the inner pilot swirler, 2 to 15% of total airflow is through the outer pilot swirler, 30 to 70% of total airflow is through the inner main swirler, and the balance through the outer main swirler.

11. The system of claim 1, wherein:

the inner and outer main swirlers each include axial swirl vanes.

12. The system of claim 11, wherein:

the axial swirl vanes are curved to reduce the Sauter Mean Diameter of a main fuel spray from the main airblast injector.

13. The system of claim 11, wherein:

the axial swirl vanes of the inner main swirler have a swirl vane angle in the range of 25 to 60 degrees; and

the axial swirl vanes of the outer main swirler have a swirl vane angle in the range of 45 to 65 degrees.

14. A fuel injection system for a gas turbine, comprising:

a pilot fuel injector;

a pilot swirler for swirling air past the pilot fuel injector;

a main airblast fuel injector;

inner and outer main swirlers for swirling air past the main airblast fuel injector; and

an air-splitter means, located between the pilot swirler and the inner main swirler, for dividing an outer pilot air stream exiting the pilot swirler from an inner

main air stream exiting the inner main swirler, and for thereby creating a bifurcated recirculation zone.

15. The system of claim 14, wherein:

the main airblast fuel injector includes an atomizer filmer lip having an aft end; and

the air splitter means has an aft end angled radially inboard and axially positioned upstream of the aft end of the atomized filmer lip of the main airblast fuel injector.

16. A fuel injector apparatus for a gas turbine, comprising:

a primary fuel injector;

a first swirler, nested about the primary fuel injector;

a second swirler nested about the first swirler;

a secondary fuel injector, nested about the second swirler;

a third swirler nested about the secondary fuel injector; and

an air splitter, nested between the first and the second swirler, and having a radially inwardly tapered inner surface defining an outlet opening, the outlet opening being disposed axially downstream of the primary fuel injector for creating a bifurcated recirculation zone.

17. The apparatus of claim 16, wherein:

the secondary fuel injector is an airblast, secondary injector having an annular fuel outlet and a pre-filming surface for providing an annular film of fuel to be entrained between the second and third swirlers.

18. The apparatus of claim 17, further comprising:

a flared outlet axially downstream of the secondary fuel injector.

19. The apparatus of claim 16, wherein:

the primary fuel injector is an airblast primary injector; and

the apparatus further includes a fourth swirler nested inside of the primary fuel injector.

20. The apparatus of claim 16, wherein:

the primary fuel injector is an axially located pressure atomizer.

21. A fuel injector apparatus for a gas turbine, comprising:

an axially located pressure atomizer first fuel injector;

a first swirler located concentrically about the pressure atomizer fuel injector;

a second swirler located concentrically about the first swirler;

a third swirler located concentrically about the second swirler;

an airblast fuel injector located concentrically between the second and third swirlers; and

an air splitter located concentrically between the first and second swirlers.

22. A fuel injector apparatus for a gas turbine comprising:

a first swirler;

a second swirler located concentrically about the first swirler;

a third swirler located concentrically about the second swirler;

a fourth swirler located concentrically about the third swirler;

an inner airblast fuel injector located concentrically between the first and second swirlers;

an outer airblast fuel injector located concentrically between the third and fourth swirlers; and

an air splitter located concentrically between the second and third swirlers.

23. A method of injecting fuel into a gas turbine, comprising:

(a) injecting a pilot fuel stream;

(b) injecting a main fuel stream concentrically about the pilot fuel stream;

(c) providing a swirling pilot air stream to entrain the pilot fuel stream;

(d) providing a swirling main air stream to entrain the main fuel stream; and

(e) splitting the pilot air stream from the main air stream and creating a bifurcated recirculation zone between the pilot air stream and the main air stream.

24. The method of claim 23, wherein step (e) further includes:

avoiding creation of a central recirculation zone.

25. The method of claim 23, further comprising:

centrifuging the pilot fuel stream into the bifurcated recirculation zone by means of the swirling pilot air stream of step (c).

26. The method of claim 25, further comprising:

anchoring a pilot flame in the bifurcated recirculation zone.

27. The method of claim 23, wherein:

step (a) includes injecting the pilot fuel stream through an axially located pressure atomizer injector;

step (b) includes injecting the main fuel stream through an airblast injector; and

step (d) includes providing inner and outer swirling main air streams inward and outward of the airblast injector.

28. The method of claim 27, further comprising:

dividing a total ~~airflow~~ airflow between the pilot air stream and the inner and outer main air streams such that:

the pilot air stream includes from 5 to 20% of total airflow;

the inner main air stream includes from 30 to 70% of total air flow; and

the outer main air stream includes the balance of total airflow.

29. The method of claim 23, wherein:

step (a) includes injecting the pilot fuel stream through a pilot airblast injector;

step (b) includes injecting the main fuel stream through a main airblast injector;

step (c) includes providing inner and outer swirling pilot air streams; and

step (d) includes providing inner and outer swirling main air streams.

30. The method of claim 29, further comprising dividing a total ~~air flow~~ airflow between the air streams such that:

the inner pilot air stream includes from 1 to 10% of total ~~air flow~~ airflow;

the outer pilot air stream includes from 2 to 15% of total airflow;

the inner main air stream includes from 30 to 70% of total ~~air flow~~ airflow; and

the outer main air stream includes the balance of total air flow.

30